

## THE GASTEROMYCETES OF AUSTRALASIA. XIV.

### THE FAMILY TULOSTOMATACEAE.

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(Plate i; seven Text-figures.)

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Under this family I have placed those genera in which the gleba, consisting of spores and a definite capillitium, is carried within a 2-layered peridium supported at the apex of a definite elongated stem (which traverses the gleba in *Podaxon*). Thus defined, the family contains the genera *Podaxon*, *Phellorina*, *Chlamydopus*, *Tulostoma*, *Queletia* and *Battarraea*, which I have arranged under the following subfamilies and tribes. This grouping is not in accordance with that of other workers, differing in several respects, as will appear.

### Family TULOSTOMATACEAE.

Plants at first subterranean, completing their development below ground, becoming elevated upon a rapidly elongating stem as they approach maturity. With a well developed peridium (of two layers, endoperidium and exoperidium) containing the gleba, carried at the apex of a simple but conspicuous stem (which traverses the gleba in *Podaxon*). Gleba consisting of spores and a well developed capillitium, of simple or branched, hyaline or coloured hyphae. Spores continuous, coloured, smooth or verrucose. Basidia bearing apically (or laterally in *Tulostoma*) sessilely or on sterigmata, 1-4 spores.

Basidia arranged in fasciculate clusters; persistent at maturity. . Subfamily Podaxonoideae.  
Peridium traversed by an axile columella . . . . . Tribe I. Podaxoneae.  
Containing one genus . . . . . 1. *Podaxon* Fr.  
Peridium carried at the apex of the stem, a columella being absent . . . . .  
 . . . . . Tribe II. Phellorineae.  
Peridium continuous with the stem, appearing as a cupulate extension of the stem  
apex . . . . . 2. *Phellorina* Berk.  
Peridium not continuous with the stem, but seated upon its truncate expanded apex. . . . .  
 . . . . . 3. *Chlamydopus* Spig.  
Basidia not fasciculate; disappearing at maturity.  
Elaters not present in the gleba . . . . . Subfamily Tulostomoideae.  
Peridium with a definite apical stoma . . . . . 4. *Tulostoma* Pers.  
Peridium opening irregularly . . . . . \*5. *Queletia* Fr.  
Elaters present in the gleba . . . . . Subfamily Battarraeoideae.  
Containing one genus . . . . . 6. *Battarraea* Pers.

### General Morphology.

The family is characterized by the fact that the peridium is carried upon a well developed stem, the wall consists of two membranes, the exoperidium and

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\* Not present in Australasia.

the endoperidium, and the gleba contains a well developed capillitium of sparsely septate, simple or sparingly branched hyphae.

The exoperidium is in *Podaxon* composed of fine or coarse fugacious scales, which frequently disappear as plants attain maturity; in *Chlamydopus*, *Tulostoma*, *Queletia* and *Battarraea* it is a well-defined membrane, although brittle and soon disappearing in mature specimens. In *Phellorina* it is persistent, and covers both stem and peridium as a continuous membrane. The endoperidium is similar in all genera, being membranous and tough. It is persistent in all save *Battarraea* (excluding *B. Digueti*). Dehiscence of the peridium is effected by a definite apical pore or stoma in *Chlamydopus* and *Tulostoma*, by irregular apical rupture in *Phellorina* and *Queletia*; in *Battarraea* it occurs as a result of circumscissile rupture of the endoperidium where this membrane junctions with the periphery of the discoid expansion of the stem apex; and in *Podaxon* by the peridium separating at its base from the stem, and becoming longitudinally lacerate.

The stem is woody and strongly developed, and carries at its modified apex the peridium, save in *Podaxon*, where it traverses the gleba as an axile columella. In *Chlamydopus* and *Battarraea* the apex of the stem is abruptly expanded to form a discoid seat for the gleba; in *Tulostoma* and *Queletia* it is inserted into a definite socket at the base of the peridium. In *Phellorina* the stem merges imperceptibly with the urceolate (at maturity) peridium. The exterior of the stem may be glabrous or covered with scales. In *Chlamydopus* and certain species of *Tulostoma* it is almost or completely smooth and often longitudinally grooved; in *Podaxon* it is covered with appressed imbricate scales, and in *Battarraea* these become noticeable as a dense fibrous covering.

The stem at its base is attached to or inserted in the so-called volva, a structure which in its most highly developed state can hardly be considered as homologous with the volva of the Phallales. It is represented merely by a bulbous expansion of the base of the stem in *Podaxon*, *Phellorina*, *Tulostoma* and *Queletia*, and consists of hyphae mixed with sand particles, though in a few specimens an appearance of an enclosing membrane is given to it by the persistence as a ring at its apex of rudiments of the exoperidium. In *Chlamydopus* this structure consists of two layers of coarsely chambered tissue, which in developing plants is filled with a mucilaginous matrix. In *Battarraea* the volva reaches its highest development, a 2-layered structure into which the stem is inserted in a conic socket. In *B. phalloides* the cavities of this tissue are in the young plant filled with a gelatinous matrix, as in *Chlamydopus*. Thus the volva would appear to be residuary tissue formed during subterranean development, and varying according to the type of peridium produced. Its ontogenetic significance is therefore slight.

In all genera the gleba consists of the spores and a well developed persistent capillitium. The latter consists of numerous simple or sparingly branched, sparsely septate hyphae, hyaline or coloured, and frequently flattened. In *Podaxon* the threads are attached to the axile columella, but are free from the peridium, so that even when the latter has quite weathered away the capillitium remains as an investing sheath enclosing the columella. In *Phellorina*, *Tulostoma*, *Queletia* and *Chlamydopus* the threads are attached to the inner wall of the endoperidium; in *Battarraea* they arise from the discoid base of the peridium, to which they are firmly attached. In this last genus they are arranged in a palisade manner, with their axes predominantly vertical.

Associated with the capillitium of *Battarraea* are numerous closed cells internally strengthened by spiral or annular thickenings, which have been termed elaters because of their close morphological resemblance to these structures in *Hepatica*. These structures are unusual in that this is the only known genus in the fungi in which they occur. Their function, manner of development and ontogenetic significance are unknown.

The basidia in all genera carry from 1 to 4 spores on short sterigmata. The spores are borne apically, save in the genus *Tulostoma*, where they are produced laterally. In the genera *Podaxon*, *Chlamydopus* and *Phellorina* the basidia occur in persistent fasciculate clusters; whereas in *Tulostoma*, *Queletia* and *Battarraea* they are produced singly and disappear at maturation of the gleba. The nature of the hymenium is unknown in genera with fasciculate basidia, so that we have no means of determining the manner in which this condition arises. In *Tulostoma* the hymenium is scarcely differentiated, basidia being produced in an irregular manner on hyphae lining barely defined glebal chambers; whereas in *Battarraea* Maublanc and Malencon (1930) have shown that a definite hymenium is produced, lining well-marked glebal chambers.

The spores present no peculiar features in *Tulostoma*, *Chlamydopus*, *Phellorina* and *Queletia*, being globose or subglobose, small in size, thin walled and regularly verruculose. In *Podaxon*, however, they are quite distinctive, and alone would serve to distinguish members of this genus, for a thick 2-layered wall is present, the spore is apically truncate, pierced by a conspicuous germ pore, and externally smooth. In *Battarraea* the spores are even more remarkable, for the wall consists of 3 distinct layers, the outer one being hyaline, somewhat subgelatinous and perforate by a large number of minute pores.

Details of development have not been worked out for any member of the family, consequently particulars of this phase cannot be given. They are especially required to determine the manner in which the fasciculate basidia of *Podaxon* and its allies arise, and to ascertain the origin of the elaters of *Battarraea*.

*Acknowledgements.*—Thanks are again due to Dr. J. B. Cleland, the University, Adelaide, for the generous manner in which he has placed at my disposal the whole of his collections of this interesting family; and to Mr. H. Drake, of this Station, for all photographs reproduced herein.

#### Subfamily PODAXONOIDEAE.

Basidia arranged in fasciculate clusters; peridium traversed by an axile columella.

##### 1. PODAXON (Desvaux).

Fries, *Syst. Myc.*, iii, 1829, 62.—*Scleroderma* Pers., *Syn. Meth. Fung.*, 1801, 150, *pro parte*.—*Podaxis* Desv., *Jour. de Bot.*, ii, 1809, 81.—*Schweinitzia* Grev., *Ed. Phil. Jour.*, viii, 1823, 257.—*Mitremyces* Spreng., *Syst. Veg.*, iv, 1827, 518, *pro parte*.—*Cionium* Spreng., *l.c.*, 529.—*Chainoderma* Mass., *Grev.*, xix, 1890, 46.

Plant at maturity consisting of a peridium borne on a strongly developed stem, which traverses the gleba as an axile columella and is firmly attached to the apex of the peridium. Peridium of two layers, a fugacious scaly exoperidium, and a persistent membranous endoperidium; dehiscing by longitudinal fissure and by becoming free from the stem at the base. Gleba of spores and a copious



capillitium, to the threads of which are attached the fascicles of basidia; capillitium threads simple, sparingly branched, scantily septate, flattened, coloured or hyaline. Spores coloured, smooth, continuous, with a 2-layered wall apically perforate by a distinct germ pore; borne on short sterigmata on the clavate or subglobose basidia.

*Habitat*.—Growing solitary in sandy soil.

*Type Species*.—*Podaxon carcinomalis* (L.) Fr.

*Distribution*.—India; Africa; North and South America; Australia.

The genus was partly included under *Scleroderma* by Persoon, then placed under *Podaxis* by Desvaux. As *Scleroderma* is used in a valid sense for a different genus, the latter name has priority; but as Fries (*l.c.*) has shown, the derivation of the term is such that it should be written *Podaxon*. Fries' ruling has been accepted by most workers, save Massee (1890), who endeavoured to revive the original *Podaxis*, but his combinations have been ignored by recent systematists.

*Chainoderma* was erected by Massee to contain an Australian plant supposed to differ in the method of dehiscence. As all other characters are identical, as the "genus" has never been met with subsequently, and as apparently no type exists, it is evident Massee erected it upon a specimen of *Podaxon*.

The peculiar fascicles of basidia are limited to *Podaxon*, *Chlamydopus* and *Phellorina*, indicating a close relationship of these three genera. Each basidium may bear from 1 to 4 spores, seated on short sterigmata. Massee (1890) claimed that the basidia were asci, and that each contained a single ascospore; but as this remarkable belief has not been supported by other workers, it is evident it was based on faulty observation. It is significant that Massee discovered basidia in his "genus" *Chainoderma*, which is a synonym of *Podaxon*. An interesting feature of the genus is the peculiar thick double wall of the spores, perforated by an apical germ pore, characters which are unusual in the Gasteromycetes.

About 30 species have been described, but owing to the great variability of most of the characters regarded as specific, it is not possible to recognize the majority of these. For the size of the plant and shape of the peridium vary in any one collection to such an extent as to render these characters valueless in specific diagnosis. Likewise the degree of roughness of the peridium would appear to have little value, since this feature depends principally upon the age of the plant at the time of collection, young plants usually appearing scaly, old and weathered specimens almost smooth. Age of the plant also affects the colour of the gleba, since, when plants are approaching maturity, the gleba is olivaceous, and as they age this colour changes through reddish-brown to black. Similarly the colour of the spores is alone of little specific value, as this feature too is affected by the age of the specimen when collected. Shape and size of the spores also in this variable genus possess little value, as variation is considerable in any one plant. After an examination of some 31 specimens in the collections of Dr. Cleland, I believe the Australian collections can be grouped under two species on the following grounds:

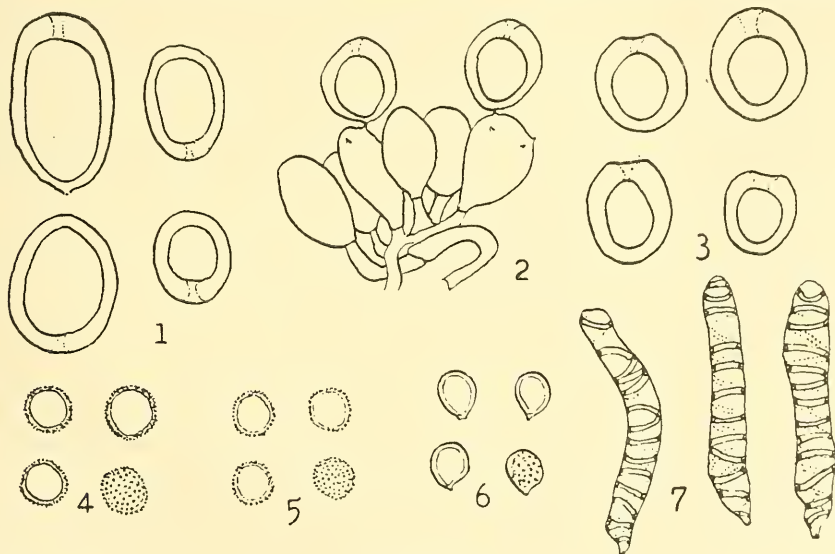
1. Capillitium copious, tough; threads deeply coloured. Spores chestnut or reddish-brown, often fuscous and opaque (*P. pistillaris*).
2. Capillitium scanty, tenuous and fragile, threads hyaline or tinted only. Spores olivaceous or pallid chestnut, not reddish (*P. loandensis*).

But even when such characters are used, many intermediate forms are encountered which can be grouped only with difficulty, and then arbitrarily upon some feature only weakly expressed.

1. *PODAXON PISTILLARIS* (L.). Plate i, figs. 1, 2; Text-figs. 1, 2.

Fries, *Syst. Myc.*, iii, 1829, 63.—*Scleroderma pistillare* (L.) Pers., *Syn. Meth. Fung.*, 1801, 150.—*Mitremyces indicus* Spreng., *Syst. Veg.*, iv, 1827, 518.—*Podaxon aegyptiacus* Mont., *Syll. gen. spec. crypt.*, No. 1044, 1856.—*P. arabicus* Pat., *Bull. Soc. Myc. Fr.*, iii, 1887, 122.—*Podaxis indica* (Spreng.) Mass., *Jour. of Bot.*, xxviii, 1890, 74.

Plant to 15 cm. tall. Peridium ovate-oblong, 3-7 cm. tall, 1-3 cm. diam.; exoperidium in the form of a few closely appressed scales, which usually fall away at maturity; endoperidium membranous, externally white or bay-brown, sometimes ferruginous, at first smooth, shining or silky fibrillose, becoming wrinkled and in old specimens longitudinally lacerate; apex bluntly acuminate or rounded. Stem to 4-8 cm. tall, 2-10 mm. diameter, covered with white, crustose, brittle fibrils, arranged irregularly (as imbricately or spirally), disappearing readily when the stem appears brown and longitudinally sulcate, smooth, often twisted, tapering from base to apex, and produced below into a bulbous attachment, consisting of hyphae and sand particles, sometimes appearing volvate due to persistence



Text-figs. 1-7.

- 1.—*Podaxon pistillaris*. Spores. The top right spore is from the form *macrosporum*; the others are taken from the same field of the typical form.
- 2.—*Podaxon pistillaris*. One of the fasciculate clusters of basidia shown in part with spores attached to the rudimentary sterigmata.
- 3.—*Podaxon loandensis*. Spores. Note the truncate apex perforated by the prominent germ pore.
- 4.—*Phellorina inquinans*. Spores showing the finely verruculose episporium.
- 5.—*Chlamydomys Meyenianus*. Spores showing the finely verruculose episporium. Note the close resemblance of these spores to the preceding.
- 6.—*Battarraea Stevenii*. Spores showing the apiculus and fine punctate markings of the episporium.
- 7.—*Battarraea Stevenii*. The peculiar elaters showing spiral and annular thickenings. These are small specimens, others in the same field attaining a much greater length. Note the basal point of attachment.

Drawings original and  $\times 1000$ .

of part of the peridium. Gleba dense, ranging in colour from olivaceous through reddish-brown to black; capillitium threads deeply coloured, olivaceous or reddish-brown, sparingly septate, scantily branched, often flattened. Spores obovate or shortly elliptical, reddish-brown,  $10-16 \times 9-12\mu$ ; truncate apically, and thickened to  $4\mu$ , frequently with a rudimentary pedicel basally, smooth, apically perforate.

*Type Locality*.—India. *Distribution*.—India; Africa; Madagascar; Australia.—Queensland: Arrabury Station, near Cordillo, 5/24\*.—South Australia: Ooldea, 8/22\*; Wilgena, 5/26, Dr. Campbell\*; Stewart's Range, 8/23, Dr. Campbell\*; near Wirrealpa, Flinders Range, 12/30\*.—Central Australia: Alice Springs to Jay River, 8/29\*; MacDonald Downs, 8/30\*.

*Forma macrosporum*: spores  $12-20 \times 12-15\mu$ . Near Wirrealpa, 12/30\*.

The characters of the species are the copious, tough, coloured capillitium threads and frequent reddish colour of the basidia and spores. The spores are variable in size, for in the majority of collections recorded above they are  $10-16 \times 9-12\mu$  (commonly  $10-12 \times 9-10\mu$ ), whereas in the form *macrosporum* they are considerably larger; but as few authors are agreed as to the size of the spores of this or any other species, and as I have found they vary considerably in different collections, it is evident spore size alone has little if any specific value in the genus. Cooke (1892, p. 223) recorded the species from Australia under the name of *Podaxis indica*, the record being based (according to Lloyd, 1905, p. 5) on a specimen at Kew from Sutton River. Lloyd also recorded it from Bourke, but under the name of *Podaxon aegyptiacus*, which appears to be a small form, not uncommon in the collections at hand. The type was described by Linnaeus (as *Lycoperdon pistillare*) from a specimen from India, which is, according to Lloyd (*l.c.*), still in his herbarium.

Judging from the published descriptions, it is probable that *Podaxon ghattasensis* P. Henn., *P. Perraldieri* Pat., *P. Chevalieri* Pat. et Har. and *P. algericum* Pat. are additional synonyms of this species.

## 2. *PODAXON LOANDENSIS* Welwitsch and Currey. Text-fig. 3.

*Trans. Linn. Soc.*, xxvi, 1868, 288.—? *Podaxon calyptratus* Fr., *Syst. Myc.* iii, 1829, 63.—? *Cionium sengalense* Spreng., *Syst. Veg.*, iv, 1827, 519.—*Podaxis axata* (Bosc) Mass., *Jour. Bot.*, xxviii, 1890, 14.—*Chainoderma Drummondii* Mass., *Grev.*, xix, 1890, 46.—*Podaxon Muelleri* P. Henn., *Hedw.*, xliii, 1904, 187.

Plants similar to the preceding, but differing in typical plants in the characters of the gleba and spores. Gleba either well developed or scanty, olivaceous or black, not reddish, arachnoid, fragile; capillitium threads hyaline or tinted only, sparingly septate and scantily branched. Spores obovate or shortly elliptical, olivaceous or chestnut-brown,  $11-15 \times 9-11\mu$ , perforate apically, basally shortly pedicellate (or as frequently without this feature), thick-walled, smooth.

*Type Locality*.—West Africa. *Distribution*.—Africa; Australia.—South Australia: Near Wirrealpa, Flinders Range, 12/30\*.

Typical plants are characterized by the fragile hyaline hyphae of the capillitium and olivaceous colour of the gleba and spores. But variation in these characters is so considerable that in many specimens it is difficult to decide as to the species

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\* An asterisk indicates that the specimens are in the herbarium of Dr. J. B. Cleland, the University, Adelaide; and where no collector is given, signifies that the collection has been made by Dr. Cleland himself.



to which they belong. For the capillitium, although fairly well developed (though fragile) in typical plants, may be scanty or almost obsolete in others. The hyphae of which it is composed are usually hyaline, but forms with tinted threads are not uncommon. In such cases the olivaceous colour of the spores is the only feature which can be used in segregation, and here too difficulty arises in that young plants of the preceding species often possess olivaceous spores, the reddish colour not developing until maturity is reached.

This plant is certainly *Podaxon Muelleri*, and has been identified as such by Lloyd (1905, p. 5), who examined the type at Berlin. It agrees equally with *P. loandensis*, the type of which is in the British Museum. It has also been listed as *P. calyptratus* by Massee (under the synonym *Podaxis axata*) and Cooke (1892, p. 223), since specimens from Australia are so labelled at Kew. Lloyd examined these and stated they were specimens of *P. Muelleri*; and Massee, after examination of the type of *P. loandensis*, considered this to be a synonym of *P. calyptratus* (his *Podaxis axata*). It is evident therefore that *P. Muelleri* and *P. loandensis* were based on collections of the plant regarded by Massee and Cooke as *P. calyptratus*. But whether this is *P. calyptratus* of Fries cannot be solved, for Fries based his species (1829) upon Bosc's illustration of *Lycoperdon axatum* (1792), and Desvaux named the same drawing *Podaxis senegalensis*, a name which has priority. As no type is extant, it becomes evident that it is mere speculation as to whether our species is that named by Fries as *P. calyptratus*; and as this name is invalid, since it was based on an illustration which cannot be identified specifically, I believe that our species should be called *P. loandensis*, with which it agrees, and of which the type is in existence.

*Chainoderma Drummondii* was evidently based on a specimen of this species in which the base of the peridium was more firmly attached than usual to the stem, and so becomes a synonym, the colour of the spores showing it to belong to this species, and not to the preceding. It is probable too that *P. squarrosus* Pat. and *P. Gollani* P. Henn. are synonyms, since the descriptions appear to agree in most particulars.

#### *Excluded Species.*

*Podaxon carcinomalis* (L.) Fr.—This was recorded by Cooke (1892, p. 223) from Australia, but I have seen no specimens which can be so referred. It differs in the more robust size of the stem and peridium, smaller size and dark reddish colour of the spores, and especially in habitat, since it has the peculiarity of growing upon termite nests.

*Podaxon anomalum* Lloyd, *Myc. Notes*, 1920, 992.—This appears to be a specimen of *Secotium*, for the description shows it cannot be a *Podaxon*. As the species was based "on a single old half specimen in bad condition", it should not have been named.

#### 2. PHELLORINA Berkeley.

Hook. *Lond. Journ. Bot.* ii, 1843, 417.—*Xylopodium* Mont., in *Dur. Fl. d. Alg.*, i, 1849, 390.—*Cypellomyces* Speng., *An. Mus. Nac. Buenos Aires*, xvi, 1906, 25.—*Whetstonia* Lloyd, *Myc. Notes*, 1906, 270.

Plant consisting of a 2-layered peridium supported upon a definite stem. Exoperidium roughened, continuous with the exterior of the stem; endoperidium

a fine parchment-like membrane seated on the expanded apex of the stem, dehiscing by the irregular breaking away of the apical portion, the whole ultimately becoming cupulate. Stem thick, woody, stout. Gleba of capillitium, spores and persistent fascicles of basidia; capillitium threads long, simple, flattened, rarely branched and sparingly septate. Spores globose, tinted yellow, verruculose. Basidia bearing apically 1-4 spores on short sterigmata.

*Habitat*.—Growing solitary in sandy soil.

*Type Species*, *Phellorina inquinans* Berk.

*Distribution*.—Africa; North and South America; India; Australia.

The genus is closely related to *Chlamydopus*, having exactly the same spores, capillitium and persistent fasciculate basidia, but is separated by the different exoperidium and method of dehiscence. The exoperidium encloses the stem and passes as an unbroken tissue to form the outer wall of the peridium. The so-called volva is but a bulbous development of hyphae and sand particles attached to the base of the stem, mixed with fragments of the walls of the peridium.

*Cypellomyces* was based on a plant with a somewhat greater development of the volva, a feature which, as R. E. Fries (*Arkiv f. Bot.*, viii, 1909, 25) has shown, has no generic value. *Whetstonia* was based on the persistent cells of the gleba, Lloyd apparently being unaware at the time of its erection that the basidia occurred in persistent fascicles. It is probable too that *Dictyocephalos* is co-generic with *Phellorina*.

About 4 species are known, of which *P. macrospora* Lloyd is confined to North America; *P. argentensis* (Speg.) R. E. Fr. to South America; *P. inquinans* Berk. to Africa, North America and Australia; *P. strobilina* to Australia.

#### 1. PHELLORINA INQUINANS Berkeley. Plate i, fig. 3; Text-fig. 4.

Hook. *Lond. Journ. Bot.* ii, 1843, 417.—*Xylopodium Delastrei* Mont., in Dur. *Fl. d. Alg.*, i, 1849, 390.—*X. australe* Berk., *Jour. Linn. Soc.*, xiii, 1872, 171.—*X. Aitchisonii* Cke. et Mass., *Grev.*, xvi, 1888, 69.—*Phellorina californica* Peck, *Forty-third Rept. N.Y. State Mus.*, 1890, 35.—*P. saharae* Pat. et Trab., *Bull. Soc. Myc. Fr.*, xii, 1896, 151.—*P. Delastrei* (Mont.) Fisch., *Nat. Pflanzenfam.*, i, 1900, 334.—? *Whetstonia strobiliformis* Lloyd, *Myc. Notes*, 1906, 270.

Plant to 9 cm. tall. Peridium pyriform, 3-5 cm. tall, 2-4 cm. diameter; exoperidium ochraceous, continuous with the stem, covered with coarse overlapping scales, which are longitudinally grooved and irregularly arranged; endoperidium membranous, shining, smooth, cream-coloured or white, continuous with the stem, rupturing by irregular breaking away of the upper surface and becoming urceolate. Stem 3-4 cm. long, 6-12 mm. diameter, solid, of two layers, an outer fibrillose scaly layer, and an inner ochraceous tough and woody layer, bulbous at the base. Gleba reddish-brown, pulverulent; capillitium threads simple, flattened, sparsely septate, tinted, almost hyaline. Spores globose, tinted yellow, 6-8.5 $\mu$ , covered with flat-topped coarse warts, appearing areolate.

*Type Locality*.—South Africa. *Distribution*.—Africa; North America, Australia.—South Australia: Herb. Kew (Lloyd, 1905, p. 10); Kinchina, Monarto South, 11/22\*; Minnie Downs, L. Reese, 7/26\*.—Victoria: Warracknabeal, F. M. Reader (Lloyd, 1905, p. 11).



According to Lloyd (*Myc. Notes*, 1923, 1199), *Xylopodium Delastreii*, *X. australe*, *Phellorina californica* and *X. Aitchisonii* are synonyms; and judging from published descriptions it is probable too that *X. Bonaciniae* Speg., *P. leptoderma* Pat. and *P. squamosa* Pat. are synonyms. *Whetstonia strobiliformis* likewise appears to be a synonym, but the description is too poor to permit of its being placed with certainty. The following species is also closely related, differing only in the much larger size of the plant and large scales of the exoperidium.

## 2. PHELLORINA STROBILINA (Kalchbrenner).

Kalchbrenner and Cooke, *Grev.*, ix, 1880, 4.—*Scleroderma strobilinum* Kalch., *Grev.*, iv, 1875, 74.—*Xylopodium ochroleucum* Cke. et Mass., *Grev.*, xv, 1887, 95.—*Areolaria strobilina* (Kalch.) De Toni, in Sacc. *Syll. Fung.*, vii, 1888, 144.

Differing from the preceding in the nature of the exoperidium, which is covered with large, thick, pyramidal, persistent, zoned scales which are larger and more prominently developed apically. Gleba and spores as in *P. inquinans*.

*Type Locality*.—Rockhampton, Queensland. *Distribution*.—Australia.—Queensland: Rockhampton (Kalch., l.c., as *Scleroderma strobilina*); Darling River (Cke. et Mass., as *Xylopodium ochroleucum*).—South Australia: Monarto South (Cleland and Cheel, 1923, p. 75).

Lloyd (*Myc. Notes*, 1921, 1072, and *Myc. Notes*, 1923, 1174) recorded 2 collections from Dr. Cleland, and in the latter case illustrated the plant with a photograph taken *in situ*, which appears to be of a specimen of *P. inquinans*. I have seen no specimens I would refer to this species.

## 3. CHLAMYDOPUS Spegazzini.

*Anal. Mus. nac. Buenos Aires*, vi, 1899, 189.

Plant consisting of a long stem bearing upon its dilated apex the 2-layered peridium. Exoperidium fragile, breaking away in pieces; endoperidium membranous, tough, persistent, dehiscing by an apical pore which enlarges as the plant ages. Stem enlarged apically, solid, supported basally in a fibrillose, cupulate volva. Gleba of spores and capillitium, threads simple or sparingly branched, immixed with numerous clusters of persistent, fasciculate basidia. Spores coloured, verrucose, globose, continuous. Basidia bearing apically, 1-4 spores on short sterigmata.

*Habitat*.—Growing solitary on sandy soil.

*Type Species*, *Tulostoma Meyenianum* Klotzsch.

*Distribution*.—North and South America; Australia.

Although *Chlamydopus* is often confused with *Tulostoma*, it has little other than a superficial resemblance to that genus. It differs in that the basidia are of the persistent fasciculate type common to *Phellorina* and *Podaxon*, whereas in *Tulostoma* they occur scattered singly, arranged in a primitive palisade lining the scarcely differentiated glebal cavities, and disappear at maturity. Spores are borne apically on the basidia of *Chlamydopus*, whereas in *Tulostoma* they are arranged laterally. These striking differences show that the genus differs considerably from *Tulostoma*, and closely approaches *Phellorina*, and these facts have been made use of in the rearrangement of the family given in preceding pages.

## 1. CHLAMYDOPUS MEYENIANUS (Klotzsch). Plate i, fig. 4; Text-fig. 5.

Lloyd, *Myc. Notes*, 1903, 134.—*Tulostoma Meyenianum* Klotzsch, *Nov. Act. Caes. Leop. Carol. Nat. Cur.*, xix, 1843, 243.—*Tylostoma maximum* Cke. et Mass., *Grev.*, xv, 1887, 94.—*Chlamydotpus clavatus* Speg., *Anal. Mus. nac. Buenos Aires*, vi, 1899, 189.—*C. Amblaiensis* Speg., *l.c.*

Peridium to 2 cm. tall, 2-3.5 cm. diameter, depressed globose or pulvinate; exoperidium fugitive, soon breaking up and falling away, of sand or other debris mixed with hyphae; endoperidium tough and membranous, ochraceous, bleaching to a pallid cream colour, smooth or finely asperate, firmly attached to the peripheral apex of the stem, dehiscing by a plane apical mouth which later becomes torn irregularly. Stem to 13 cm. tall, and 12 mm. diameter, woody, solid, grooved longitudinally, silky fibrillose or with a few coarse peeling scales, sometimes arranged as an annulus in old specimens, ochraceous, attenuate below and seated in a fragile volva of two layers, gradually thickened above and expanded into a flattened, discoid, truncate apex. Gleba ochraceous or yellowish-brown; capillitium densely developed, of long hyaline or tinted threads attached both to apex and inner wall of the endoperidium. Spores globose, tinted yellow, 6-9.5 $\mu$ , mostly 7-8 $\mu$ , covered with coarse, flat-topped warts, appearing areolate.

*Type Locality*.—Peru, South America. *Distribution*.—North and South America; Australia.—South Australia: Miller's Creek, 8/21, Dr. Campbell\*; Minnie Downs, 7/26\*; no loc., Mr. Zietz\*.—West. Australia: Kurrawang, 7/18, Mrs. A. F. Cleland\*; Gascoyne River (Cke. et Mass., *l.c.*, as *Tylostoma maximum*); Kalgoorlie, 6/17\*.

The volva is quite a distinct feature in this genus, and is of a coarsely chambered tissue, the cavities of which are in young plants filled with a gelatinous matrix. The stem is cellular and tissue-like, and is also partially filled with matrix when young.

Hollos (*Gast. Ungarns*, 1904, p. 45) examined the type of *Tylostoma Meyenianum* at Berlin and found it to be identical with the illustration and description of *Chlamydotpus clavatus*; and Lloyd examined the type of *Tylostoma maximum* at Kew and found it to be a specimen of the same species.

## Subfamily TULOSTOMOIDEAE.

## 4. TULOSTOMA Pers.

This genus has been dealt with in a former paper (*Proc. Linn. Soc. N.S.W.*, i, 1925, 245-258); but to make it comparable with other genera treated in this paper an artificial key to the species is given below.

*Key to the species of Tulostoma.*

Mouth definite.

Mouth tubular, margin entire.

Spores finely verruculose, often almost smooth.

Peridium smooth or practically so ..... *T. albicans* White.

Peridium finely pubescent ..... *T. pubescens* G. H. Cunn.

Spores distinctly echinulate, aculeate or warted.

Peridium uncoloured (dingy white or pallid tan).

Peridium smooth.

Spores 5-8 $\mu$  ..... *T. McAlpinianum* Lloyd.

Spores 9-13 $\mu$  ..... *T. macrosporum* G. H. Cunn.

Peridium rough with the adhering persistent exoperidium .....  
..... *T. adhaerens* Lloyd.

Peridium deeply coloured.

Peridium chestnut brown, mouth more deeply coloured than the peridium  
..... *T. brumale* Pers.<sup>(1)</sup>

Peridium chocolate brown ..... *T. Purpusii* P. Henn.

Mouth fibrillose-fimbriate.

Spores perfectly smooth ..... *T. obesum* Cke. et Ell.<sup>(2)</sup>

Spores finely but minutely verruculose ..... *T. minutum* White.

Spores distinctly echinulate, aculeate or warted.

Spores closely echinulate-verrucose ..... *T. subfuscum* White.

Spores with echinulae arranged in striae ..... *T. striatum* G. H. Cunn.

Mouth indefinite.

Mouth merely an indefinite torn aperture.

Spores smooth ..... *T. pulchellum* Sacc.<sup>(3)</sup>

Spores minutely verruculose ..... *T. australianum* Lloyd.<sup>(4)</sup>

#### Subfamily BATTARRAEIOIDEAE

##### 5. BATTARRAEA Persoon.

*Syn. Meth. Fung.*, 1801, 129.—*Dendromyces* Liboschitz, *Beschr. neu entd. Pilzes*. 1814, f. 1.—*Sphaericeps* Welw. et Curr., *Trans. Linn. Soc.*, xxvi, 1870, 290.

Plant with a small applanate peridium borne upon a long and strongly developed stem seated in a basal volva. Peridium of 2 layers; exoperidium of sand particles mixed with hyphae, soon disappearing, endoperidium tough and membranous, dehiscing by circumscissile cleavage of the upper hemisphere from the periphery of the discoid apex of the stem. Gleba of spores and capillitium; capillitium of two types, long sparsely branched threads, and elaters. Spores globose, punctate, of 3 layers, the outer being somewhat gelatinous. Basidia bearing 1-4 spores apically on long sterigmata.

*Habitat*.—Growing solitary, partially buried in sand.

*Type Species*, *Battarraea phalloides* (Dicks.) Pers.

*Distribution*.—Europe; Asia; North and South America; Africa; Australia.

The genus may be recognized by the manner in which the small pulvinate peridium, usually naked at maturity, is borne on the greatly expanded discoid apex of a stout, greatly elongated stem, and by the manner of dehiscence. The capillitium is copious and consists of hyphae mixed with numerous elaters, arranged in a dense palisade. The elaters are short closed cells which internally contain spiral or annular thickenings. The spores, too, are characteristic, for the wall consists of 3 layers, the outer one being perforated with numerous punctate openings.

<sup>(1)</sup> Some doubt exists as to whether the spores of this species are finely verruculose or whether they are distinctly warted. I have examined specimens from Europe (ex herb. Bresadola) and from England (ex herb. Kew) and find that they are distinctly sparsely warted, the warts not being so pronounced as other species included in the section. Our plants agree with these European plants exactly, so that there is little doubt but that the species occurs in this region.

<sup>(2)</sup> On page 254 of the paper cited above, I recorded this species as *T. poculatum* White. Coker and Couch (*Gasteromycetes*, 1928, p. 155) have shown this to be a synonym of the earlier named *T. obesum*. *T. gracile* White and *T. kansense* Peck appear to be additional synonyms.

<sup>(3)</sup> As Lloyd (*Myc. Notes*, 1923, p. 1233) examined the type of this species, and found it to be a plant with indefinite mouth and smooth spores, it is placed under this section.

<sup>(4)</sup> Re-examination of specimens of this species shows the spores to be minutely verruculose (hence the reference to their being smooth in the original diagnosis); so that the species is included under this section. *T. Readeri* Lloyd and *T. egranulosum* Lloyd appear to be synonyms, since they possess almost identical features, having the same indefinite mouths, finely verruculose spores and roughened exoperidia.



Although the genus may be recognized readily, the species are confusing, for of the 15 which have been named, but 3 can be recognized with certainty. Of these, *B. phalloides* (Dicks.) Pers. is characterized by the gelatinous volva and interior of the stem in young specimens; it is known with certainty to occur only in Britain and Europe. *B. Digueti* Pat. et Har. is characterized by the persistent endoperidium, and is limited to North America. *B. Stevenii* (Lib.) Fr. is separated from the first by the non-gelatinous volva, and from the second by the dehiscent endoperidium. It has apparently a wide range through Europe, North and South America, Africa and Australia. Most records of *B. phalloides* appear to be based on this plant, which is the sole representative of the genus in this region.

The name of the genus was derived from Antonio Battara, and was spelled *Batarrea* by Persoon; in 1804 it was changed to *Battarea* by Beauvais, and in 1825 to *Battarrea* by Fries, though in his later work of 1829 this author again used the older spelling of Persoon. Finally Maublanc and Malencon in 1930 used *Battarraea*, which, being the correct derivation of the name, is used in this paper.

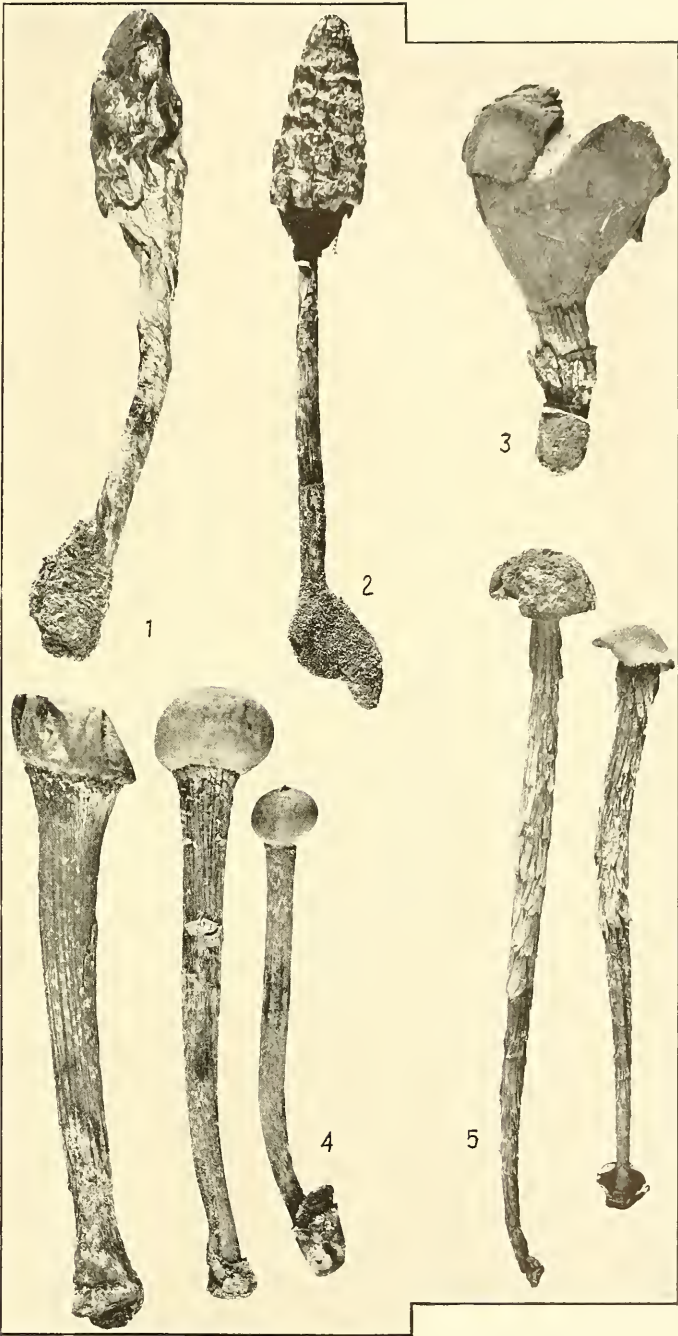
1. *BATTARRAEA STEVENII* (Liboschitz). Plate i, fig. 5; Text-figs. 6, 7.

Fries, *Syst. Myc.*, iii, 1829, 7.—*Dendromyces Stevenii* Lib., *Beschr. neu entd. Pilzes*, 1814, f. 1, 2.—*Batarrea Gaudichaudii* Mont., *Ann. Sci. Nat.*, ser. 2, ii, 1834, 76.—*Sphaericeps lignipes* Welw. et Curr., *Trans. Linn. Soc.*, xxvi, 1870, 290.—*Battarrea Guicciardiniana* Ces., *Atti d. R. Accad. sci. fis. e mat.*, vii, 1875.—*B. Muelleri* Kalch., *Grev.*, ix, 1880, 3.—*B. Tepperiana* Ludw., *Bot. Centralbl.*, xxxvii, 1889, 337.—*B. laciniata* Undw., ex White, *Bull. Torr. Bot. Club*, xxviii, 1901, 439.

Peridium pulvinate or depressed globose, seated on the expanded discoid apex of the stem, to 6 cm. diameter, and 2-3 cm. tall, base white or ochraceous and appearing roughened when the gleba is removed, smooth and white beneath; apically at first consisting of two membranes, the outer falling away in flakes, the inner dehiscing circumscissilely and falling away in one piece as a distinct calyptra. Stem 10-35 cm. tall, 5-15 mm. diameter, tapering below and attached to the substratum by a definite 2-layered volva (which is not gelatinous at any time of its development), covered externally with numerous, coarse, overlapping scales, which are more numerous and coarse apically, ochraceous or bay-brown, weathering away ultimately and exposing the cream-coloured, fluted exterior, hollow or stuffed with silky fibres. Gleba pulverulent, with a capillitium of two types, single hyaline threads predominantly vertically arranged, and elaters which are fusiform or cylindrical bodies with annular or spiral thickenings on the inner wall. Spores globose or subglobose, often apiculate, 5-7 $\mu$ , commonly 5-5.5 $\mu$ , finely and sparsely punctate.

*Type Locality*.—Russia. *Distribution*.—Europe; Asia; North and South America; Australia.—New South Wales: Baan Baa, 1/17\*; Barellan, 7/18, Miss D. Balfour\*.—South Australia: Tapley's Hill Road, J. A. Kelley\*; Monarto South\*; Murray Bridge, 7/21, Mr. Ashby\*; Nankeri, 5/21, Prof. Osborn\*; Normansville, 1924, Dr. Morgan\*; Grange, near Adelaide, 1926\*; Adelaide Hospital, 5/28\*.—West. Australia: Kurrawang, 1918, 1921, Mrs. A. F. Cleland\*.

This species is the most widely distributed of the three known species, and has in consequence been listed under numerous names, as the synonymy shows. It is probable that *B. levispora* Mass. from India, *B. franciscana* Copeld. from California, *B. Guachiparum* Speg. and *B. patagonica* Speg. from Argentine are also



Gasteromycetes of Australasia.—Tulostomataceae.